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Synthetic Fiber Industry- A Story in Industrial Location

Leonard D. Goranson
Southern Arkansas University

THE SYNTHETIC FIBER INDUSTRY
A STUDY IN INDUSTRIAL LOCATION

Leonard D. Goranson
Southern State College

During the past three or four decades, the use of man-made fibers for textiles has had a phenomenal increase in the United States. Per capita consumption of synthetic fibers rose from just under 0.8 per cent of all textile fibers used during the period, 1920-24, to a high of 20.61 per cent of all fibers used by the textile industry in the period, 1950-1954.[1] In terms of the total amount of man-made textile fibers consumed, 459 million pounds were used in 1939, and approximately 2,243 million pounds in 1953.[2] The 1954 Census of Manufactures gives the total value of products shipped by the synthetic fiber industry as 1,244.5 million dollars for that year. The value added by manufacture was approximately 447.9 million dollars in 1947 compared with 720.5 million for 1954, or an increase of about 60 per cent.[3] From the forecast made in April 1955 in a leading trade publication for the synthetic fiber industry, it is estimated that by 1965 synthetics will supply almost 30 per cent of the textile fibers used in the United States.[4]

Increased use of synthetic fibers has had a salutary effect on the textile industry in several ways. Man-made fibers have considerably more price stability than do natural fibers. A stable cost

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[1] Robert C. Shook, "You Can Expect Big Future Gains for Man-Made Fibers," Modern Textiles, 36 : 39, April, 1955.

[2] Ibid., p. 40.

[3] 1954 Census of Manufactures, Advance Report, Series MC-28-2.1, Bureau of Census, Department of Commerce, Washington, D. C., p. 1.

[4] U.S. Consumption of man-made fibers for 1956 was 26% of total fibers consumed, and for the first half of 1957 (latest figures available), it was approximately 27% of the total. Encyclopedia Americana, Annual for 1958, p. 764. New York, Americana Corporation. 1958.

of raw materials makes for more stable industry, all other things being equal. Mill operators like to use these new fibers because of their greater price stability. Their use helps to reduce some of the risk and uncertainty in textile manufacturing. Better working conditions have come to the industry, too, in part because of the use of synthetics. Mills are cleaner, air conditioning is more widely used and textile machinery has been improved for use in processing the new materials.[5] Thus, both directly and indirectly, benefits have come to the industry as a whole through the use of these new fibers.

We have then, a rapidly expanding new industry which in a few decades has become an important supplier of textile fibers. Where this industry has located, the factors which influenced its location and which are likely to influence the location of its continuing expansion, are questions which present a challenge for investigation and research.

Geographers have long used methods of visual correlation to determine whether or not there is any apparent association between different factors on mapped data. This has been done often simply by comparing two sets of mapped data side by side or by superimposing transparent tracings of mapped data one upon another or upon a more finished map. There has, however, long been felt a need for some more quantitative method than these for determining something of the degree of association between two or more sets of factors having areal variation in their distributions. Among other attempts along this line, a study was conducted in 1956 at the Geography Department of the State University of Iowa, using statistical techniques as a method of quantifying the association observed to exist between different industries. The results of this study are published in a monograph entitled The Measurement of Association in Industrial Geography.[6]

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5 , "Synthetics Threaten to Take Over," Business Week, Sept. 4, 1954, p. 93.

6 Harold H. McCarty, John C. Hook, and Duane S. Knos, The Measurement of Association in Industrial Geography, Department of Geography, State University of Iowa, Iowa City, Iowa, 1956.

It seemed desirable to use such statistical correlation methods as described in this monograph for the measurement of association between the synthetic fiber industry and such industries and other factors as might be expected to be found in varying degrees of association with it. However, this method requires quantitative data by either counties or metropolitan areas, for the industries and other factors between which we expect to find an association. And the Census of Manufactures, even the most recent one, that for 1954, does not have such data for the synthetic fiber industry except for two or three states, and then only for the state as a whole rather than at a county or other level. It was at once apparent that even though data might be available for associated industries in the Census of Manufactures, some other source of information would have to be sought for data on the synthetic fiber industry.

Two sources were found which together yielded the necessary information. Davidson's Rayon, Silk and Synthetic Textiles,[7] a handbook published for the textile industry, gives a complete listing of all manufacturing plants producing synthetic textile fibers in the United States and Canada. Editor and Publisher Co.'s Market Guide,[8] an advertisers' service covering the circulation areas for most of the newspapers published in the United States, was the other. From this source it was possible to compile, by counties, the number of workers employed in almost all manufacturing plants producing synthetic textile fibers in a twelve-state area along the Atlantic seaboard. The output of such manufacturing establishments was not obtainable, but the number of workers employed in manufacturing has for some time been recognized as a fairly reliable measure or index of a given industry. In the first study ever made of the manufacturing belt of North America, it was observed that the percentage of total workers employed at manufacturing in cities of over ten thousand pop-

[7] Davidson's Rayon, Silk and Synthetic Textiles, Ridgewood, N.J., Davidson Publishing Co., 1957, pp. 344-359.

[8] _____, Market Guide, New York: Editor and Publisher Co., Inc., Issues for 1954 and 1955.

ulation varied, fairly constantly, with the percentage of total value of manufactures of the state which was produced in those cities.[9] Careful consideration of that investigation reveals that its conclusions were reached scientifically and objectively. The University of Iowa study on the measurement of association in industrial geography also used the number of workers employed in manufacturing, by counties and metropolitan areas, as a measure of the various industries.[10] This index was used for both the dependent variable and the independent variables for measuring, by statistical correlation, the association between the various iron and steel and machinery industries.

It is assumed, therefore, that the number of workers employed in an industry is a fairly reliable measure of the variations in the distribution of that industry. For our investigation of the synthetic fiber industry the number of workers, by counties, was chosen as the measure to be used. The number of workers employed in the various associated industries, by counties, was also used as a measure of these independent variables for the measurement of geographical association by statistical correlation.

As listed by Davidson's Handbook of synthetic fiber manufacturing, the industry is located in twenty-one states east of the Mississippi with plants in seventy counties scattered throughout these states. Since complete data on workers employed by the industry could be obtained for only twelve of these states it was necessary to confine the study to the forty-eight counties having synthetic fiber manufacturing within the twelve states.[11]

The 1954 Census of Manufactures classifies under industry 2825, Synthetic Fibers, only the chemical and cellulosic fibers. Metallic and glass fi-

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[9] DeGeer, Sten, "The American Manufacturing Belt," Geografiska Annaler, Stockholm, 1927, pp. 248-249.

[10] McCarty, op. cit., p. 67.

[11] Connecticut, Massachusetts, Rhode Island, New York, New Jersey, Delaware, Maryland, Pennsylvania, West Virginia, Virginia, North Carolina, South Carolina.

bers, which also are used in the manufacture of textiles, are classified in other categories. The industry itself, however, as represented by its leading periodical, regards all man-made fibers used in textile manufacturing as synthetic textile fibers. The reason for this seeming discrepancy is the fact that the census grouping of Industry 2825, Synthetic Fibers, is a further breakdown of the secondary census group 282, Organic Chemical Products. Since metallic and glass fibers are mineral rather than organic chemical products they must be classified otherwise than with the synthetic fiber group in the Census of Manufactures.

Rayon is a generic name applied to all man-made fibers made from cellulose. Viscose and acetate are names applied to processes for making rayon and also to the fibers so produced. Originally cotton linters were the main source of cellulose for production, but now about three-fourths of the cellulose used in synthetic fibers comes from wood pulp.

Non-cellulosic is a term usually applied to the newer synthetics, which are sometimes also called "miracle fibers" or "true synthetics" in order to distinguish them from the older fibers produced from cellulose. Nylon and several of the other new synthetics are made from hydrocarbons derived from coal, petroleum and natural gas.[12] "From petrochemicals comes an ever-increasing number of new fibers."[13] Such products as orlon, dacron, mylar, and acrilan fall in this category. There are also the synthetics produced by chemical processing of certain proteins. Vicara is a fiber made from corn protein. Casein fibers derive their protein raw material from milk. Other fibers have been produced using protein from peanuts and soybeans.

For purposes of this paper, synthetic textile fibers are defined as they are by the textile industry. That is, metallic and glass fibers, as well as the cellulosic fibers and the newer synthetics or "miracle fibers" are classed as synthetic textile fibers.

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[12] Product Information, Fibers by DuPont, Wilmington, Delaware: E. I. DuPont de Nemours & Co., Inc., 1957, p. 7.

[13] _____, "Clothed in Oil and Gas," Science News Letter, 61:242, April 19, 1952.

As was previously noted, the value of output in manufacturing has been found to vary directly with the number of workers employed. In like manner, a given industry may be found to vary, fairly constantly, with another industry or with some other factor which has areal differentiation in its geographic distribution. Thus, it may be hypothesized that where X is found Y will also be found in a greater or lesser degree of association with it. Or the correlation may be in an inverse order so that where a large degree or concentration of X occurs a small degree of Y will be found, and vice versa.

For statistical measurement of associations of this kind, the Pearson product moment coefficient of correlation has been found to be the best suited.[14] The symbol r is used to designate this coefficient in simple correlation, that is, where the association between only two variables is being tested as in the X and Y example above. The symbol R is used to designate this coefficient in multiple correlation where the association between a given dependent variable and several other independent variables is being tested. The symbols r^2 and R^2 designate the square of the coefficient of simple or multiple correlation and represent an index which is sometimes called the coefficient of determination. This is a measure of the degree of association also, and indicates the per cent of variation in the dependent variable which can be "explained" by the variations of the independent variable, or independent variables in the use of multiple correlation.

The dependent variable in this study is the number of workers employed from county to county in the synthetic textile fiber industry. As to the independent variables, it is necessary at this point to formulate certain hypotheses regarding the association between this industry and other industries or other factors which may be associated with it in areal distribution. Since the synthetic fiber industry may be expected to be part of an in-

[14] Harold H. McCarty, John C. Hook, and Duane S. Knos, The Measurement of Association in Industrial Geography, Department of Geography, State University of Iowa, Iowa City, Iowa, 1956, p. 67.

dustrial complex, it should be found in areas where there are other industries, especially where there are industries providing it with raw materials and where there are industries (namely, the textile and apparel industries) constituting a market for its production. With these probable associations in mind the following associations are hypothesized for the synthetic fiber industry.

"The Industrialized Location Hypothesis." The number of workers employed in the synthetic fiber industry will vary directly with the total number of workers employed in manufacturing and with the number of workers employed in the chemicals industry. (1954 Census of Manufactures Major Group No. 28.)

"The Raw Materials Orientation Hypothesis." The number of workers employed in the synthetic fiber industry will vary directly with the number of workers employed in the pulp and paper industry, (Major Census Group No. 26); and with the number of workers employed in the petroleum and coal processing industries, (Major Census Group No. 29). This latter group includes by-product coke ovens and petroleum refineries.

"The Market Orientation Hypothesis." The number of workers employed in the synthetic fiber industry will vary directly with the number of workers employed in the textile industry, (Major Census Group No. 22); and with the number of workers employed in the apparel industry, (Major Census Group No. 23).

Sub-hypothesis: The number of workers employed in the synthetic fiber industry will vary inversely with the average annual wage. The rationalization behind this sub-hypothesis is the fact that low wages are usually given as a principal reason for the location of the textile industry; especially of the flight of textiles to the southern states. Thus the sub-hypothesis is considered to be a part of the market of orientation hypothesis.

Values for the Pearson product moment coefficient of correlation theoretically may vary from 1.00, indicating a perfect correlation between the variables, to -1.00, indicating a perfect negative or inverse correlation or association between them. The smaller the value of the coefficient (that is, the nearer 0.00), the smaller is the amount of association between the variables. A coefficient value of 0.00 would indicate a total lack of cor-

relation or no association whatever between the variables. The following table lists the values obtained for r, the coefficient of correlation computed separately in simple correlation of each of the independent variables with the dependent variable, the synthetic fiber industry.

COEFFICIENTS OF CORRELATION AND DETERMINATION FOR SIMPLE CORRELATION OF INDEPENDENT VARIABLES WITH THE SYNTHETIC FIBERS INDUSTRY (1954)

	Variable	r	r^2
X_{01}	Total Workers in Manufacturing	.3366	.1133
X_{02}	Textiles (22)	.3749	.1406
X_{03}	Apparel (23)	.2947	.0868
X_{04}	Pulp and Paper (26)	.2871	.0624
X_{05}	Chemicals (28)	.5755	.3311
X_{06}	Petroleum and Coal (29)	.1933	.0373
X_{07}	Average Annual Wage	.2223	.0494

Since the average annual wage showed a positive value of .2223 for r this indicated a direct variation rather than indirect as hypothesized in the sub-hypothesis. For this reason the sub-hypothesis had to be abandoned. A multiple correlation was then computed using the remaining six independent variables and an R value of .6690 was obtained. Squaring this R the value of R^2 was found to be .4475. This is taken to indicate that approximately 45 per cent of the variation in the synthe-

tic fiber industry, by county units, in 1954, can be "explained" statistically or accounted for by the variations in the six independent variables taken together in multiple regression or correlation.

Limited space forbids the inclusion of raw data for the 493 counties in the twelve-state area covered in the study. Computations were made on an electric calculator to obtain the sums of squares and sum of products needed to compute coefficients of correlation. The following formula was used to compute both the coefficients of simple correlation and also coefficients of partial correlation between the various independent variables which were needed to compute the R or coefficient of multiple correlation.

$$r = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)(\Sigma y^2)}} = \frac{\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{N}}{\sqrt{\left[\Sigma X^2 - \frac{(\Sigma X^2)}{N}\right]\left[\Sigma Y^2 - \frac{(\Sigma Y^2)}{N}\right]}}$$

In these equations the sums of squares and sum of products of the deviations from the mean represented by the small x and y are derived from the second equation in which the capital X and Y represent the raw score data computed on the calculating machine.

The following table or correlation matrix gives the coefficients of partial correlation between the various independent variables.

Consideration of the table of coefficients computed for simple correlation of the several independent variables taken one by one to measure their association with the synthetic fiber industry leads to several conclusions. The fact that the highest degree of association is found with the chemicals industry may be partially discounted since the synthetic fiber industry is itself a part of the chemicals industry. The next highest degree of association is found to be with the textile industry indicating that the orientation towards its market is stronger than towards the suppliers of raw materials for the synthetic fiber industry.

In other words, there is a tendency for synthe-

		(TWM) X_1	(22) X_2	(23) X_3	(26) X_4	(28) X_5	(29) X_6
X_1	(TWM)	1.0000	.5449	.2174	.7675	.4907	.5373
X_2	(22)		1.0000	.3215	.5021	.3710	.6450
X_3	(23)			1.0000	.4661	.3322	.1652
X_4	(26)				1.0000	.6442	.4901
X_5	(28)					1.0000	.4567
X_6	(29)						1.0000

The formula for computing the R or coefficient of multiple correlation is:

$$R_{X_{0.1,2,3,4,5,6}} = \sqrt{1-(1-r^2_{X_{0.1}})(1-r^2_{X_{0.2,1}})(1-r^2_{X_{0.3,2,1}})(1-r^2_{X_{0.4,3,2,1}})(1-r^2_{X_{0.5,4,3,2,1}})(1-r^2_{X_{0.6,5,4,3,2,1}})}$$

X_0 here is equivalent of Y above.

tic fiber manufacturing plants to be located with respect to their raw materials supply, but the tendency is even stronger for them to be located with respect to the market for their product. As to future location of this expanding industry, it seems likely that it will tend to be drawn towards the textile industry where the market for its product is found.